HURRICANE SURVEY

INTERIM REPORT

CONNECTICUT COASTAL AND TIDAL AREAS

U.S. Army Engineer Division, New England
Corps of Engineers
Waltham, Mass.

22 May 1964

SYLLABUS

Tidal flooding in past hurricanes and other severe storms has caused considerable damage to public and private properties along the shoreline of Connecticut and created flood and erosion problems of serious consequence. Three severe hurricanes have struck the state in the past 26 years with the most severe occurring on 21 September 1938. This storm caused tidal flooding along the Connecticut shore to elevations ranging from about 9.2 to 11.7 feet above mean sea level. In the next most severe hurricane, on 31 August 1954, flood stages approximated the 1938 level from the west limit of Stratford to the east limit of Madison. At other locations along the Sound, the 1954 stage was zero to 1.6 feet below the 1938 level.

The occurrence today of flooding to the record 1938 level, with no hurricane protection projects in operation, would cause losses estimated at over $51,300,000. Completed protection works at Pawcatuck would reduce this by approximately $1,400,000. The construction of five projects that have been either authorized or favorably recommended for Connecticut

at Stamford, Westport, Stratford, New London and Mystic would together effect an estimated reduction of about $13,600,000. The total reduction attributable to the six projects is over $15,000,000 which is equivalent to about 29 percent of the total estimated loss. The remaining damages of $36,300,000 are widely distributed, over more than 400 miles of shoreline making it impractical to provide hurricane tidal flood protection to or above the 1938 level. Previously constructed and recommended beach erosion control measures, in addition to preserving much of the present shorefront, would also serve to effect some reduction in the flood and wave damages caused by hurricanes and other severe storms. It is concluded that it would be desirable for local interests to give serious consideration to the following measures to lessen future tidal-flood losses:

1. Adherence to their present emergency mobilization measures for the evacuation and accommodation of flood plain residents during flood periods; and periodically notifying residents in the flood-prone areas of the flood danger and apprising them of plans and programs for emergency warning and evacuation.

2. Reviewing from time to time the adequacy of their present emergency evacuation programs, modifying and expanding such programs as found necessary and desirable, taking into account such factors as the need for improvement of escape or evacuation routes.

3. The adoption of zoning regulations to control development within the flood plain.

4. The adoption of building regulations establishing minimum elevations for first floors in new construction, and requiring improved construction methods in areas subject to flooding.

5. The completion of previously recommended measures to control the erosion of the beaches and preserve the shoreline.

The Division Engineer recommends that no further improvements for hurricane protection in the coastal and tidal areas of Connecticut be undertaken by the United States at this time.

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U. S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASS. 02154

ADDRESS REPLY TO:
DIVISION ENGINEER

REFER TO FILE NO.
NEDED-R

22 May 1964

SUBJECT: Hurricane Survey Report on Connecticut Coastal and Tidal Areas

TO: Chief of Engineers
ATTN: ENGCW-PD
Washington, D. C.

AUTHORITY AND INTRODUCTION

1. In view of the severe damages experienced in the eastern and southern coastal areas of the United States by the occurrence of hurricanes, the 84th Congress on 15 June 1955 adopted Public Law No. 71 which authorized the Corps of Engineers to undertake a study of means to prevent the loss of human lives and damages to property from hurricane tidal flooding.

The authorizing legislation provides that first consideration be given to areas where severe damages have occurred. Studies have therefore been completed on a number of Connecticut areas resulting in (1) the construction of a protective project at Pawcatuck, (2) the authorization of projects at Stamford, Westport, New London and Mystic, (3) the submission of a favorable recommendation to Congress on a project for Stratford, and (4) the submission of an unfavorable report on protection at Fairfield. Detailed information on each of these seven projects is available in the individual survey reports. The studies for this report cover the remaining Connecticut coastal areas for which previous hurricane survey reports have not been prepared. The results of these studies are intended to serve as a guide for future planning and to encourage the adoption of measures which will further the work initiated by the Federally-constructed and authorized projects.

DESCRIPTION

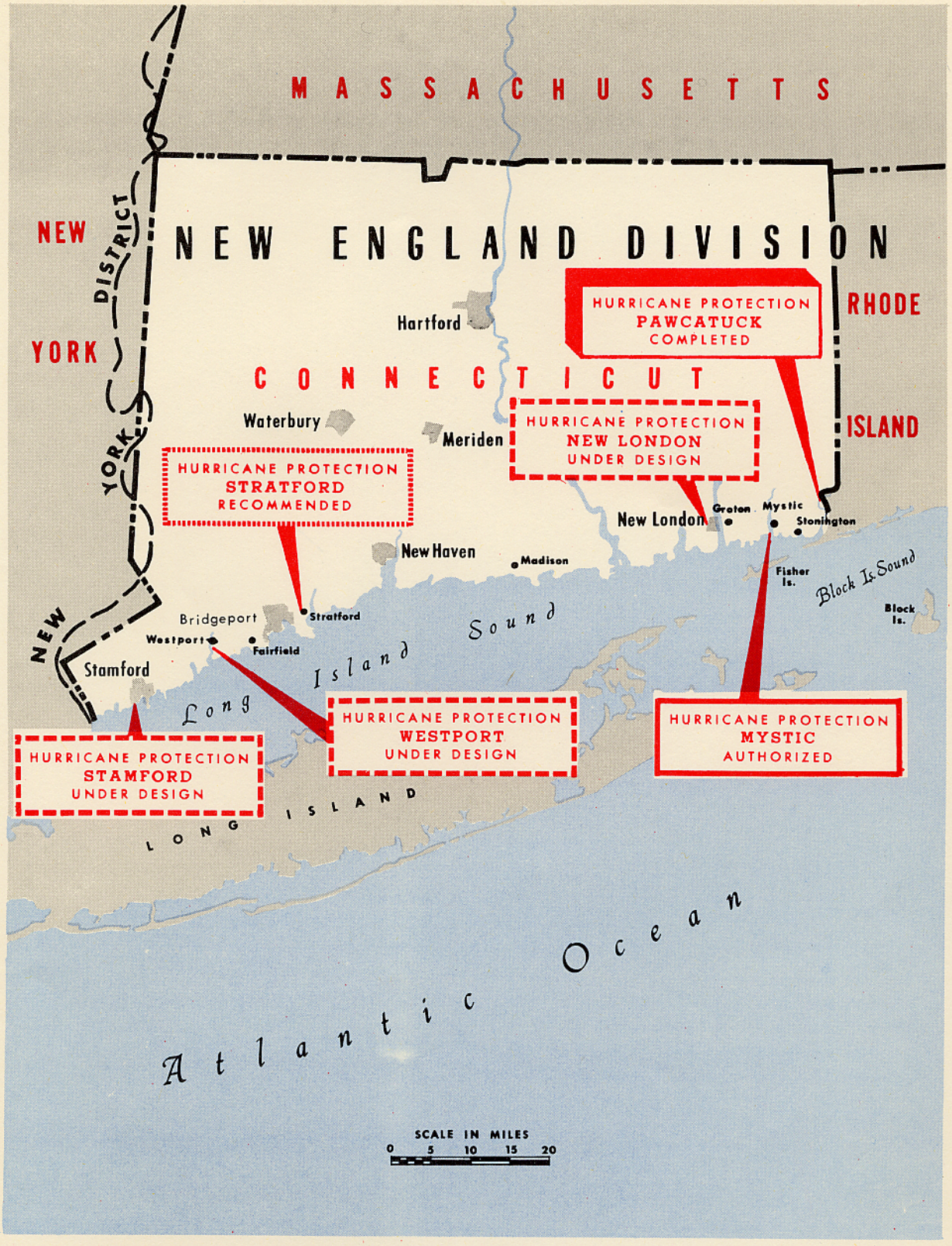
2. The coastline of Connecticut extends along the north shore of Long Island Sound from the mouth of Byram River, at the New York-Connecticut State line, northeasterly to New Haven Harbor thence easterly to the Pawcatuck River, at the Connecticut-Rhode Island State line, a total length of about 180 miles. The entire shoreline is irregular and marked by numerous bays, coves, estuaries and promontories. Among the principal indentations in the shoreline are the harbors at Greenwich, Stamford, Norwalk, Bridgeport and New Haven, and the estuaries of the state's three major rivers, the Housatonic, Connecticut and Thames. The total tidal shoreline of the 24 cities and towns along the Sound, plus four others along the Thames River below Norwich, measures about 430 miles. The Housatonic, Connecticut and Thames Rivers, which respectively drain the western highlands, central lowlands, and eastern highlands of the State, are all important commercial waterways. They are also extensively used by recreational craft. In addition to these three major rivers, the lower reaches of a number of smaller streams constitute portions of important harbors that are used for commercial navigation and recreational boating.

Approximately 80 miles, or nearly 45 percent of the 180 miles of shoreline along the Sound, consists of sandy beaches that are utilized for public and private recreation. Nearly 50 miles of the total shoreline are rocky, about 30 miles are composed of coarse gravel and cobbles, and nearly 20 miles are marshy.

ECONOMIC DEVELOPMENT

3. GENERAL

Manufacturing, commercial navigation, recreational boating, and the accommodation of tourists and summer visitors are important factors in the economic welfare of the 28 Connecticut cities and towns along the Sound and the lower Thames River estuary. The area is served by a network of



U.S. Army Engineer Division, New England
Corps of Engineers
Waltham, Mass.

LOCATION MAP

highways. The main line of the New York, New Haven and Hartford Railroad closely parallels the entire shorefront with branch and other lines affording connections to northern points. Public airports are available in Stratford, New Haven, Waterford and Groton. The United States Coast Guard Academy and the U. S. Naval Submarine Base are located on the Thames River above New London. The Electric Boat Company, an important builder of submarines, is located on the New London Harbor waterfront in Groton.

4. POPULATION

The year-round population of the 28 Connecticut cities and towns in the study area was 960,626 in 1960, an increase of about 21 percent over 1950. This represents approximately 38 percent of the total population of the state. The population of the coastal cities and towns increases markedly during the summer, as a result of an influx of summer vacationists, with several of the towns experiencing increases of upwards of 300 percent in the summer.

5. INDUSTRY

The principal industrial centers along the coast include Norwalk, Bridgeport, Stratford, New Haven and New London. There are over 2,000 industrial plants in the area varying from small one-man operations to factories employing over 5,000. Among the more important industries in terms of employment are those engaged in the manufacture of aircraft, electrical equipment and machinery, and the fabrication of metals.

6. NAVIGATION AND COMMERCE

There are 27 authorized navigation projects in Connecticut. Most of these have been completed or practically completed. Twelve are now utilized principally for the benefit of commercial navigation and include the deep-draft ports of New Haven and Bridgeport, with a project depth of 35 feet, New London with a project depth of 33 feet, and the Thames River improvement of 25-foot depth. Channels varying in depth from 12 to 18 feet are available in the Connecticut River to Hartford, the Housatonic River to Derby and Shelton, and at other industrial

and commercial centers such as Stamford and Norwalk. There are 10 projects, with improved channel depths ranging from 6 to 15 feet, which are used chiefly by recreational craft at the present time. Four of these have been constructed solely to meet the demands of recreational boating. The remaining five of the 27 projects in Connecticut, with channel depths of 6 to 12 feet, are utilized to a considerable degree by recreational craft but also carry a significant amount of commercial tonnage.

The total waterborne commerce in Connecticut in 1962, including both receipts and shipments, amounted to about 18.4 million tons. Over 99 percent of this total was handled at the five major ports of Stamford, Norwalk, Bridgeport, New Haven and New London and on the Housatonic, Connecticut and Thames Rivers. About 12,000,000 tons, or 64 percent of the total 1962 commerce, consisted of the receipts of petroleum and petroleum products and about 3,000,000 tons, or 16 percent of the total, consisted of the receipt of bituminous coal.

7. RECREATION

The provision of services associated with outdoor recreational activity is of growing importance in the economic welfare of the Connecticut coastal communities. Their favorable location with respect to the densely populated southern section of New England and the adjoining New York area causes an increasing demand on the recreational facilities of the area. One-fourth of the entire population of the United States is located within 300 miles of the area. Numerous opportunities for bathing, recreational boating, and fishing are afforded by Long Island Sound and the many bays, coves, and streams along the coast of Connecticut. There are 25 miles of public and 55 miles of private beach fronting on Long Island Sound. Included in the publicly-owned shore frontage are nearly five miles of beaches at four state-owned parks - Sherwood Island in Westport, Hammonasset in Madison, Rocky Neck in East Lyme, and Harkness Memorial in Waterford. The state reported attendance at these four parks in 1962 of nearly 2.5 million or about 50% of the total attendance that year at all of the 38 state-owned parks. Attendance at the four shorefront parks has increased 16 percent in the last five years even though the attendance and use at Hammonasset, the largest of the four, has been near capacity for a number of years. Two new coastal

parks, Silver Sands in Milford and Bluff Point in Groton, will be opened in the near future, making available to the public an additional 1.5 miles of beach. Supplementing the state parks are a number that are city or town-owned. These include facilities such as the Cummings and Cove Island Parks in Stamford, Compo Beach in Westport, and Short Beach at Stratford.

Boating is one of the more important recreational activities in the coastal towns. At the present time there are about 300 public and private installations for the construction, repair, mooring, docking and servicing of recreational boats along the 430 miles of the state's tidal shore line. Over one-third of these facilities have been constructed since 1950. Many of the older facilities have been enlarged or altered in recent years to meet the requirements of the ever-increasing numbers of recreational craft plying the Sound.

HURRICANE TIDAL FLOODING

8. The history of hurricanes in Connecticut dates back to the storm of 19-20 October 1770 during which two vessels were driven ashore at New London. The distribution of recorded hurricane occurrences along the Connecticut coast since that time, by estimated degree of intensity, is shown in the following table.

TABLE 1

HURRICANE OCCURRENCES, CONNECTICUT COAST

Number of Occurrences

Period	Severe Tidal Flooding	Damage from wind and rainfall*	Threat to area	Total events
1700-1800	1	2	1	4
1801-1900	5	8	4	17
1901-1963	3	15	27	45
Totals	9	25	32	66

*Usually accompanied by high seas and moderate tidal flooding.

The fact there is a record of 45 hurricane experiences in the period 1901 to 1963, compared to 21 occurrences in the period 1770 to 1900 indicates a lack of records on storm occurrences prior to 1900 rather than a trend toward increased hurricane activity in recent years.

The hurricanes and storms that caused the most severe tidal flooding in recent times, listed in their order of magnitude for the greater part of the coast, were those that occurred in 1938, 1954, 1950 and 1944. For a distance of nearly 35 miles along the Sound, between Stratford and Madison, the 1938 and 1954 tidal flood levels were approximately equal. Tidal stillwater levels associated with the two major hurricanes experienced in 1938 and 1954 are given in Table 2 below, for several locations along the Connecticut coast.

TABLE 2

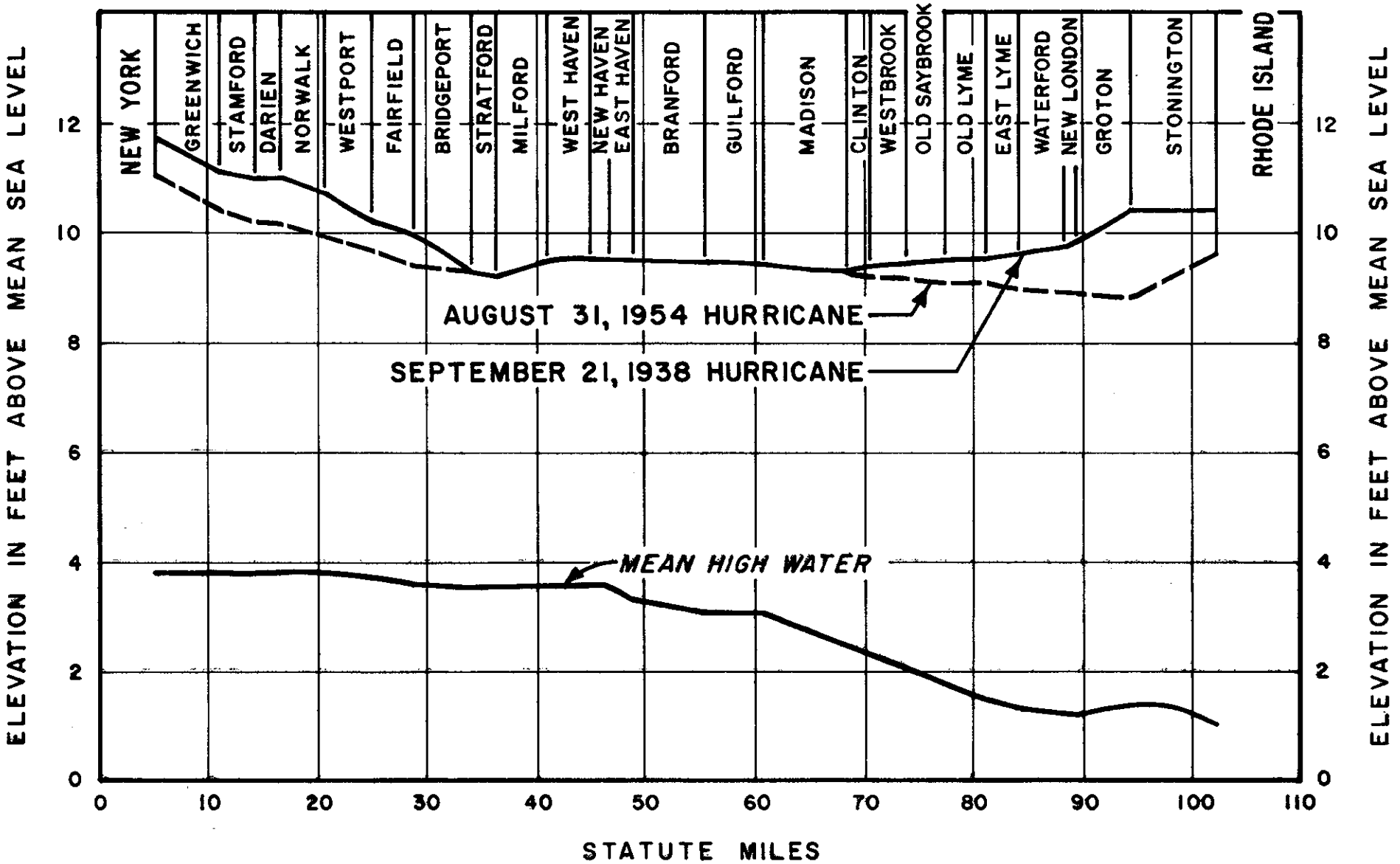
HURRICANE TIDAL STILLWATER LEVELS

CONNECTICUT COAST

Location	Normal High Tide (feet msl)	Hurricane Stillwater Level Sept. 21, 1938 (feet msl)	Aug. 31, 1954 (feet msl)
Greenwich (1)	3.9	11.7	11.0
Norwalk	3.8	10.8	10.2
Bridgeport	3.6	9.6	9.3
New Haven	3.5	9.5	9.5
Saybrook	1.9	9.4	9.1
New London	1.2	9.7	8.9
Stonington (2)	1.0	10.4	9.6

(1) At western limit of town
(2) At eastern limit of town

Peak flooding along the coast during the 1938 hurricane occurred from one and one-half to two hours before the time of normal high tides, and in the 1954 hurricane, from zero to thirty minutes before. This timing contributed significantly to the severity of flooding upon these two occasions. A profile showing the heights of tidal flooding along the Connecticut coast in the 1938 and 1954 hurricanes is shown on the following page.



HURRICANE FLOOD LEVELS - CONNECTICUT

Consideration of the hurricane tidal flood problems along the coast presents the possibility that the record levels of the past may be exceeded in the future. Studies indicate that under conditions of a very severe hurricane, timed so that its surge would strike coincident with the top of a mean spring tide, flooding can be anticipated to tidal elevations three to six and one-half feet above the record level experienced along the Connecticut coast.

HURRICANE PROTECTION PROJECTS

9. In response to the Congressional directive contained in Public Law No. 71, detailed investigations have been made of areas along the Connecticut coast where heavy concentrations of tidal-flood damages have been experienced. These studies have resulted in the construction, authorization, or favorable recommendation of protective works at six localities as listed in Table 3, below.

TABLE 3

TIDAL-FLOOD PROTECTION PROJECTS, CONNECTICUT

Project	Location	Status	Estimated Cost (1963 Price Level)
Stamford	Stamford	Under design	$ 7,400,000
Compo Beach	Westport	Under design	310,000
Stratford	Stratford	Recommended	6,200,000
New London	New London	Under design	3,430,000
Mystic	Groton and Stonington	Authorized	2,130,000
Pawcatuck	Stonington	Completed 1963	945,000

In addition to the above, a survey report has been submitted on the tidal-flood problem at Fairfield. The study determined that a protection project at this locality would prevent losses of about $1,000,000 in a recurrence of 1938 conditions. Owing to the lack of public support, no project was recommended.

HURRICANE TIDAL-FLOOD DAMAGES

10. Past damages from hurricane tidal-flooding have been extensive. Surveys made after the 1938 and 1954 events reveal large property losses. A recurrence of the most recent severe hurricane, in August 1954, would cause losses of over $33,000,000 from tidal flooding in Connecticut. All of the 24 cities and towns along the Sound and four others along the Thames River would share in this total with the four principal centers of damage, Stamford, New London, Groton, and Stonington collectively accounting for about 45 percent of the total loss. The damages that can be expected in a recurrence of the two great hurricanes of 1938 and 1954, with no protection, and the damages that would be prevented by the six Federal projects are given in Table 4 on the following page.

A recurring 1938 hurricane under present conditions and with no protective projects in operation would cause losses from tidal flooding of over $51,300,000. The completed protection at Pawcatuck would reduce this by approximately $1,400,000 and the five additional projects that have been authorized or favorably recommended would together reduce the losses by an estimated $13,600,000. The total reduction attributable to the six projects ($15,000,000) is equivalent to about 29 percent of the total loss that would be experienced in a future hurricane of 1938 severity with no protective works in operation.

TABLE 4

HURRICANE TIDAL-FLOOD DAMAGES
CONNECTICUT COASTAL AND TIDAL AREAS
(Thousands of Dollars - 1963 Price Level)

Location	Recurring 1954 Hurricane	Recurring 1938 Hurricane	Recurring 1938 Damages Preventable by Federal Projects(1)
Greenwich	700.0	900.0	-
Stamford	3,300.0	6,200.0	5,600.0
Darien	500.0	600.0	-
Norwalk	1,200.0	2,100.0	-
Westport	1,100.0	1,400.0	300.0
Fairfield	700.0	1,500.0	-
Bridgeport	900.0	2,000.0	-
Stratford	1,500.0	1,500.0	1,300.0
Milford	500.0	500.0	-
West Haven	200.0	200.0	-
New Haven	1,000.0	1,000.0	-
East Haven	700.0	700.0	-
Branford	1,400.0	1,300.0	-
Guilford	200.0	200.0	-
Madison	700.0	700.0	-
Clinton	200.0	300.0	-
Westbrook	700.0	900.0	-
Old Saybrook	1,200.0	1,400.0	-
Old Lyme	1,700.0	2,000.0	-
East Lyme	1,000.0	1,100.0	-
Waterford	300.0	400.0	-
New London	4,300.0	5,500.0	3,200.0
Montville	700.0	900.0	-
Norwich	1,200.0	5,200.0	-
Preston	minor	minor	-
Ledyard	minor	minor	-
Groton	2,600.0	5,100.0	1,600.0
Stonington	4,900.0	7,700.0	3,000.0(2)
Totals	33,400.0	51,300.0	15,000.0

(1) Projects completed, authorized or favorably recommended.
(2) Includes $1,400,000 creditable to completed Pawcatuck project.

ADDITIONAL HURRICANE PROTECTIVE MEASURES

11. Many miles of available sandy beaches outside the existing or authorized project areas are extensively used during the summer and numerous estuaries and coves along the shore attract recreational boating. As the population continues to expand and recreational pressures become even more intense, the provision of protective measures to retain these valuable resources will be found desirable.

Protective measures for reducing tidal-flood damages fall into the following general classes:

a. Positive protective structures. These measures include structures such as barriers, with gated or ungated openings, which would completely or partially close off a waterway to the entry of hurricane tides; dikes and seawalls ... which would hold back the high water; and breakwaters which would effect a reduction in the height of hurricane waves. Measures to protect and restore the shore, such as rock revetment and beach raising and widening, would offer partial flood protection to inland properties. Such work can be combined with other water resource development measures as they become desirable and economical.

b. Flood proofing, strengthening, or relocating existing buildings. Following Hurricane "Carol" in 1954, a number of homes and other buildings within the flood zone were relocated or raised to place their first floor level above the height of expected future hurricane tides. To further mitigate future losses, consideration should be given to the permanent relocation of goods and equipment to higher floor levels, relocation out of the flood plain, flood proofing and more substantial construction to resist the destructive forces of high water and waves.

c. Restrictive zoning regulations and building codes. The adoption of flood plain zoning regulations and modified building codes requiring sturdier construction can be effective steps in governing the future development of flood prone areas to make them less vulnerable to the hazards of hurricane tidal flooding.

d. Hurricane warning and emergency flood mobilization measures. These measures, coupled with plans for evacuation, including the improvement of escape routes, are feasible measures to lessen property damages in future storms. All of the Connecticut towns along the Sound have programs in effect that provide for the evacuation of residents from flooded areas and their accommodation during the emergency period. These evacuation programs, together with the hurricane warning services now provided by the U.S. Weather Bureau, are essential supplements to other protection plans for the area. An example of mobilization measures that can be taken is contained in a report entitled "A Model Hurricane Plan for a Coast Community." This report was prepared in 1959 by the Weather Bureau, U.S. Department of Commerce, in collaboration with the Corps of Engineers.

SHORE EROSION

12. The many miles of sandy beaches along the Connecticut shore, interspersed with numerous headlands, are important assets to the local communities and shorefront property owners. The principal problem is one of deterioration and gradual erosion of the beaches with the average yearly recession varying from a fraction of a foot to several feet per year at the more vulnerable locations. Destruction of the shorefront has been most serious during hurricanes and other severe storms. The problem becomes more intense as use of the shorefront for recreation increases.

Cooperative beach erosion control studies, covering the entire coast of Connecticut, were made between 1949 and 1957 and 11 reports thereon prepared and submitted to Congress. (See Appendix A for listing of prior reports). Subsequently, Congress authorized Federal participation in 20 projects for the improvement of publicly-owned shore frontage in 12 communities. These 20 projects together entailed the placement of sand on 67,500 feet of beach and riprap on 700 feet; the construction of groins, jetties and training walls; and the extension of existing protective works. The recommended work has been substantially completed by the State of Connecticut with the exception of the placement of sand on 2,800 feet of Greenwich Beach and the placement of sand on 10,000 feet of beach and the construction of 11 groins at Milford. The cost of the completed work, which covers about 60 percent of the public beach front, has been $3,600,000 including $1,000,000 contributed by the Federal Government.

The reports also recommended 29 projects, in 10 towns, for the improvement of privately-owned shores by local interests, with no Federal participation. These 29 projects together provide for the placement of sand on 57,200 feet of beach, and riprap on 1,900 feet; the construction of groins, jetties and training walls; and the extension of existing groins. Of this recommended work, local interests have placed sand on 8,200 feet of beach and riprap on 700 feet, at 4 locations, at a total cost of $590,000.

Local interests have also spent about $200,000 in the placement of sand fill along 11,200 feet of beach at three locations in Bridgeport-Stratford, Branford and Clinton. Shore improvement work at four other localities (Norwalk, Fairfield, Stratford and New London), at an estimated cost of $1,000,000, are being planned by the State for accomplishment in 1964, and projects at three additional localities (West Haven, East Lyme and Groton) are being planned for 1965.

The projects recommended for local accomplishment in previous reports were found to be warranted at the time the reports were prepared. The growing demand for shorefront properties in recent years and a resulting increase in property values would indicate a desirability for completion of this work. The projects, in addition to providing benefits from the reduction in shore erosion, will provide reductions in wave and flood damages in hurricanes and other storms.

SHORE RESTORATION AND PROTECTIVE MEASURES

13. The restoration, protection and improvement of shore areas is a desirable first step toward preventing loss of life and reducing damage to property in future hurricanes. The natural beaches and headlands of Connecticut form an essential line of defense against hurricanes and other storms. Since there is an inadequate supply of beach-building material, artificial provision of material must be considered to replace losses or to restore the beaches to meet future expected increaseed usage. This may be accomplished by:

a. Creating a supply by placement of a stockpile of sand on the beach where it can be distributed by wave action along the length of the beach.

b. Creating a supply by construction of dunes along the backshore, and nourishment of the beach through natural erosion of their seaward face.

c. Artificial beach building through direct placement of sand on the beach with the rate of loss retarded by a groin system.

The erosion of headlands may be decreased by placing rock revetment along the toe of the slope or by the construction of seawalls or bulkheads.

IMPROVEMENTS CONSIDERED

14. The principles of hurricane tidal flood protection, shore protection, and related water resource development have been applied to each of the 24 Connecticut cities and towns subject to tidal flooding which were not covered, or were only partially covered, by earlier interim hurricane survey reports. General plans, based upon sound coastal engineering practices, were developed for the areas of concentrated damages in each of these communities. These general plans are outlined in Appendix D to serve as a guide to future integrated public and private development. It was found in each case that, under present economic conditions and current requirements for Federal participation, additional hurricane protection would not be warranted for various reasons including the wide distribution and scattered nature of damages, the cost of construction and the reluctance of local interests to participate in the cost of protective measures at this time. Hurricane protection plans were evaluated both alone and as multiple-purpose projects in conjunction with completed or recommended beach erosion control measures.

DISCUSSION AND CONCLUSIONS

15. A recurrence today of the hurricane of September 1938, which caused the record level of tidal flooding in Long Island Sound, would result in tidal flood damages in excess of $51,300,000 in 28 Connecticut coastal cities and towns. Operation of the completed Pawcatuck project together with the four authorized projects at Stamford, Westport, New London and Mystic, and the recommended project

for Stratford would reduce the damages in a recurring 1938 hurricane by over $15,000,000. Studies made for this report sought possible solutions to the hurricane tidal-flood problems remaining after the protection that would be afforded by the six Federal hurricane protection projects which have been completed, authorized or proposed. Although no additional Federal improvements for hurricane flood control are recommended at this time, the studies may serve as a guide and point of departure for future coastal protection facilities.

Other measures can lessen the effect of future storms and should be considered. Completion by local interests of the numerous improvements previously recommended in the interest of beach erosion control would be effective in preserving much of the shore front and serve to effect some reduction in the flood and wave damages that would be experienced in future hurricanes, particularly storms of less severity than the one in 1938. Flood plain zoning, flood proofing of buildings, warning systems and emergency evacuation plans are needed to reduce future damages. To assist the State and communities in disseminating information on flood hazards, maps of flood-prone areas and records of tidal flood elevations and frequencies have been prepared. From a long-range viewpoint, shore protection and erosion control measures can be constructed when warranted to protect against hurricanes and severe storms; to preserve the beaches; and to meet the pressures and needs of a growing population.

It is concluded that it would be desirable for local interests, both public and private, to give serious consideration to the following measures to lessen future damages and prevent loss of life from tidal flooding.

a. Adherence to their present emergency mobilization measures for the evacuation and accommodation of flood plain residents during flood periods; and periodic notification of residents in the flood-prone areas of the flood danger and availability of plans and programs for emergency warning and evacuation.

b. Reviewing from time to time the adequacy of present emergency evacuation programs, modifying and expanding such programs as found necessary and desirable, taking into account such factors as the need for improvement of escape or evacuation routes.

c. The adoption of zoning regulations to control development within the area of tidal flooding.

d. The adoption of building regulations establishing minimum elevations for first floors in new construction, and requiring improved construction methods in areas subject to flooding.

e. The completion of measures that have been previously recommended to control the erosion of the beaches and preserve the shore line. The protection and improvement of the natural beaches of Connecticut is desirable since they form a first line of defense against hurricanes and other storms and are an important recreational asset.

RECOMMENDATIONS

16. It is recommended that no further improvements for hurricane protection in the coastal and tidal areas of Connecticut, in addition to those presently authorized or favorably recommended in prior reports for construction at Stamford, Westport, Stratford, New London, and Mystic, be undertaken by the United States at this time.

It is further recommended that this report, with appendices, be printed to serve as a guide to public and private interests in their long-range planning for the full development of the lands, waters and other natural resources of the Connecticut coastal area.

It is also recommended that this report be accepted as complying in full with the directive authorizing the hurricane study of the Connecticut coastal area.

P. C. HYZER
Brigadier General, USA
Division Engineer

HURRICANE SURVEY

INTERIM REPORT

CONNECTICUT COASTAL AND TIDAL AREAS

APPENDICES

U.S. Army Engineer Division, New England
Corps of Engineers
Waltham, Mass.

22 May 1964

HURRICANE SURVEY
CONNECTICUT COAST

APPENDICES

APPENDIX A - PRIOR STUDIES AND REPORTS

APPENDIX B - HISTORY OF HURRICANES AND OTHER STORM OCCURRENCES

APPENDIX C- DESIGN STUDIES AND HYDRAULICS

APPENDIX D - CONSIDERED PROTECTION PLANS

APPENDIX A

PRIOR STUDIES AND REPORTS

APPENDIX A

APPENDIX A

PRIOR STUDIES AND REPORTS

A-1. Tabulated below are the 7 interim hurricane survey reports on Connecticut coastal areas that have been submitted in compliance with the authorization of Public Law 71, 84th Congress, approved June 15, 1955, and the 10 reports on a cooperative beach erosion control study of the state that have been prepared under the provisions of Section 2 of the River and Harbor Act approved July 3, 1930, as amended and supplemented.

TABLE A-1

PRIOR REPORTS - CONNECTICUT COASTAL AREA

Area or Locality	House Document	Congress	Sess.	Year
Interim Hurricane Survey Reports				
Stamford, Conn.	210	86	1	1959
Westport, Conn.	412	87	2	1962
Fairfield, Conn.	600	87	2	1962
New London, Conn.	478	87	2	1962
Mystic, Conn.	411	87	2	1962
Pawcatuck, Conn.	212	86	1	1959
Stratford, Conn.	(Report of Chief of Engineers submitted to Secretary of the Army, 29 January 1964)			
Beach Erosion Control Studies				
Area 5, Pawcatuck R. to Thames River, Conn.	31	83	1	1952
Area 10, Thames R. to Niantic Bay, Conn.	334	85	2	1957
Area 6, Niantic Bay to Connecticut River, Conn.	84	83	1	1953
Area 4, Connecticut River to Hammonasset River, Conn.	514	82	2	1952
Area 5, Hammonasset River to East River, Conn.	474	81	2	1950
Area 9, East River to New Haven Harbor, Conn.	395	84	2	1957

Area or Locality	House Document	Congress	Sess.	Year
Beach Erosion Control Studies (cont.)				
Area 3, New Haven Harbor to Housatonic River, Conn.	203	83	1	1953
Area 7, Housatonic River to Ash Creek, Conn.	248	83	2	1953
Area 1, Ash Creek to Saugatuck River, Conn.	454	81	2	1950
Areas 8 and 11, Saugatuck River to Byram River, Conn.	174	85	1	1957

A-2. Other recent reports of interest in connection with studies of the hurricane and shore protection problems along the Connecticut coast are listed below:

a. The following chapters (unpublished) of Part Two of the report on the "Land and Water Resources of the New England-New York Region," (Senate Document No. 14, 85th Congress, 1st Session), prepared by the New England-New York Inter-Agency Committee, pursuant to presidential directive of October 9, 1950:

(1) Chapter XVII- Pawcatuck River Basin
(2) Chapter XX- Thames River Basin
(3) Chapter XXI- Connecticut River Basin
(4) Chapter XXII- Housatonic River Basin
(5) Chapter XXIII-Connecticut Coastal Area
(6) Chapter XXIV- Special Subjects, Subregion "B", Volume 2 - Harbors and Beaches, Connecticut, and other subjects.
(7) Chapter XXXIX-Special Subjects, Regional, Volume 4 - "Hurricanes"

b. Shore Protection Planning and Design, Technical Report No. 4, Beach Erosion Board, Office, Chief of Engineers, May 1961. This report presents techniques for the solution of shore protection problems.

APPENDIX B

HISTORY OF HURRICANES AND OTHER STORM OCCURRENCES

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HISTORY OF HURRICANES AND OTHER STORM OCCURRENCES

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APPENDIX B

HISTORY OF HURRICANES AND OTHER STORM OCCURRENCES

B-1. GENERAL

In order to forecast the possibility of future hurricane occurrences, a review has been made of historical data on past hurricanes that have struck or threatened the coast of Connecticut. Since the eastern entrance of Long Island Sound lies in the path of hurricanes moving into New England from the south, the Connecticut coastline, on the north shore of the Sound has frequently been subject to tidal flooding from hurricane surges moving west up the Sound. The records indicate that the coast of Connecticut has experienced or has been threatened by hurricane tidal flooding upon 66 occasions since 1769. The greater number of these hurricanes, owing to the locations of their paths, did not cause tidal flooding along the Connecticut shore. However, they did present a potential threat of such flooding. Of the 9 hurricanes that have caused severe tidal flooding, the 5 greatest, as far as can be determined from existing records, are listed below in their estimated order of magnitude.

21 September 1938
24 August 1893
31 August 1954
15 September 1815
14 September 1944

In recent years, the hurricanes that caused tidal flooding along the coasts of Rhode Island and southern Massachusetts also caused flooding along the Connecticut coast. Prior to 19 October 1770, five hurricanes are known to have affected the coastal areas of Massachusetts and Rhode Island. The two earliest of these storms, namely those of 15 August 1635 and 3 August 1638, caused extensive tidal flooding, probably the greatest ever experienced in New England during the past 200 to 300 years. Since there was very little development along the Connecticut shore until after 1638, there are no available records to indicate that these storms affected Long Island Sound. It is reasonable to assume, however, that they did cause inundation of the coastal lowlands of Connecticut.

Since the extent of flood damages is relative to the degree of development in the areas flooded, the early great hurricanes were not as damaging as those of the present century. As a matter of fact, the two earliest hurricanes of record in New England,

which according to history must have been very severe, occurred prior to the establishment of settlements along the Connecticut coast. The recurrence of these two hurricanes under present conditions would cause extensive damages, possibly in excess of the damages sustained in September 1938.

B-2. SUMMARY OF HURRICANE AND STORM OCCURRENCES

A total of 66 hurricanes are known to have either hit or threatened the Connecticut coast since 1768. These storms have been classified with respect to their effect on the coast as indicated below:

Type "A" - Hurricanes causing severe tidal flooding
Type "B" - Hurricanes causing damage from wind and rainfall (usually accompanied by high seas and moderate tidal flooding)
Type "C" - Hurricanes threatening the area.

In the latter case, (Type "C") a slight change in meteorological conditions could have caused any of these hurricanes to follow a course more critical to Long Island Sound, thereby subjecting the Connecticut coastal area to tidal flooding.

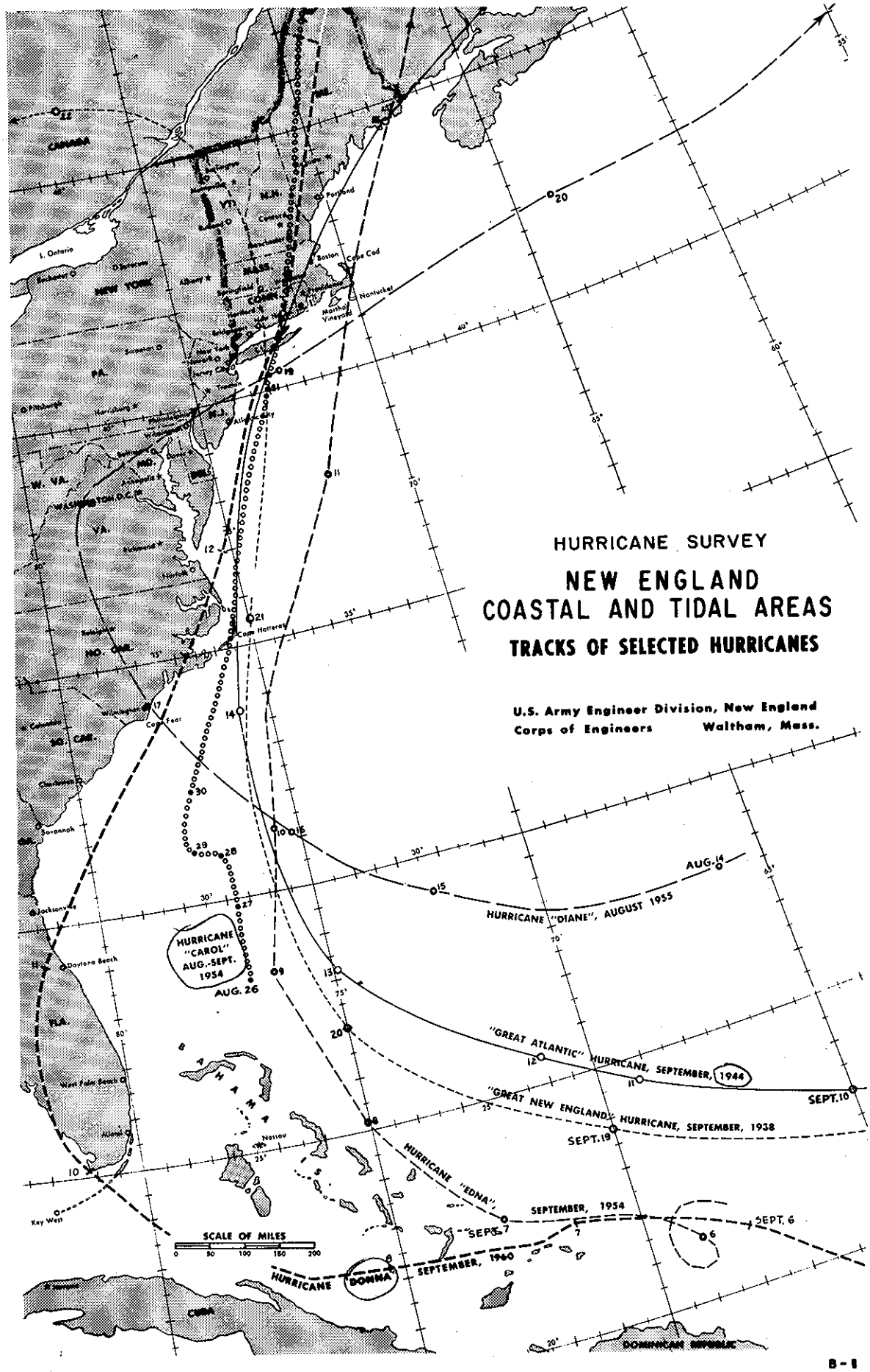
Of the 66 hurricanes of record since 1769, 9 are of type "A", 25 of type "B" and the remaining 32 of type "C". Forty-five of the listed hurricane experiences (3 type "A", 15 type "B", and 27 type "C",) have occurred during the period from 1901 to 1963, inclusive. The fact that there is a record of 44 hurricanes in this 63-year period, as compared with 21 in the 131-year period from 1770 to 1900, inclusive, is not considered indicative of a greater trend in hurricane activity in recent years but to a lack of records and information on storms prior to 1900.

A summary of the occurrences of hurricanes and other severe storms that have struck or threatened the Connecticut coast with tidal flooding, together with brief historical descriptions of those that caused damage, are contained in the six individual survey reports that have been previously prepared on Stamford, Westport, Stratford, New London, Mystic, and Pawcatuck, Connecticut.

B-3. HURRICANE TRACKS

The tracks of three notable hurricanes causing tidal flooding and serious damages along the Connecticut coast, namely, those of September 1938, September 1944, and August 1954, and

Hurricane Diane, August 1955, which brought record rainfall to many areas in southern New England, are shown on Plate B-1.


HURRICANE SURVEY
NEW ENGLAND
COASTAL AND TIDAL AREAS
TRACKS OF SELECTED HURRICANES
U.S. Army Engineer Division, New England
Corps of Engineers Waltham, Mass.
HURRICANE "DIANE", AUGUST 1955
AUG. 14
HURRICANE "CAROL" AUG.-SEPT. 1954
AUG. 26
"GREAT ATLANTIC" HURRICANE, SEPTEMBER, 1944
SEPT. 10
"GREAT NEW ENGLAND" HURRICANE, SEPTEMBER, 1938
SEPT. 19
HURRICANE "EDNA", SEPTEMBER, 1954
SEPT. 6
HURRICANE DONNA, SEPTEMBER, 1960
SEPT. 7
SCALE OF MILES
0 50 100 150 200
CANADA
NEW YORK
PA.
W. VA.
VA.
MD.
DEL.
N.J.
CONN.
R.I.
MASS.
VT.
N.H.
ME.
WASHINGTON D.C.
Boston
Cape Cod
Nantucket
Marthas Vineyard
Cape Hatteras
Cape Fear
Charleston
Savannah
Jacksonville
Daytona Beach
West Palm Beach
Miami
Key West
Nassau
BAHAMAS
CUBA
DOMINICAN REPUBLIC
FLA.
S. CAR.
N. CAR.

APPENDIX C

DESIGN STUDIES AND HYDRAULICS

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DESIGN STUDIES AND HYDRAULICS

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APPENDIX C

DESIGN STUDIES AND HYDRAULICS

C-1. DESIGN CRITERIA

The design of structures has followed published standards of the Chief of Engineers and the Coastal Engineering Research Center. Design wave heights would be from 6 to 16 feet with periods of 6 to 13 seconds. The significant wave height, the average of the highest one-third of the waves in a wave train, is used in determining the stone sizes for slope protection, the top elevations of the various structures in the plan, and the height of wave run-up. The wave heights at the toe of the protective works are calculated on the premise that the maximum wave height that can be sustained is equal to 0.78 times the depth of water at the toe. Wave run-up was computed for a large number of different combinations of composite and simple slopes and berm widths by the method outlined in "Wave Run-up on Composite Slopes" (1), and a design selected to prevent or minimize overtopping of the protective structures. The assumption was made that the run-up on rock slopes would be reduced 50 percent because of the increased roughness factor. Rock sizes and the thicknesses required for the cover, bedding and filter layers were based on the technical paper, "Laboratory Investigations of Rubble-Mound Breakwaters" (2), dated June 1957, using a Kd displacement factor of 3.2 and "Wave Forces on Rubble-Mound Breakwaters and Jetties" (2) dated September 1961.

C-2. PROTECTIVE STRUCTURES

The most practical protection for shorefront cottage developments, fronting on existing beaches consists in most instances of the placement of sand fill to raise and widen the beach and constructing an earth-filled, rock-faced dike along the landward limit of the fill. Design of the fill includes a berm with a minimum width of 50 feet and a top elevation ranging, in general, from about six to eight feet above mean spring tide dependent on location on the coast and the level of tidal flooding for which the project is being designed. Design of the dike includes consideration of the effect of erosion of the berm, wave setup on the berm, size of wave breaking on the dike and the allowable quantity of overtopping during a hurricane. (See Plate D-4 for typical section.

(1) By Thorndike Saville, Jr., Coastal Engineering Research Center, Washington, D. C.
(2) By Robert Y. Hudson, Waterways Experiment Station, Vicksburg, Mississippi

Diking alone has been considered in the following instances:

(1) The protection of property along rocky shores or waterfront areas where the maintenance of new beach fill is considered impractical.

(2) Protection of properties located back from the shore.

(3) To effect closure between shorefront protection and high ground to the rear. In cases where limitations are presented by reason of space restrictions, concrete walls or sheet steel piling are utilized in lieu of dikes.

HYDRAULICS

C-3. HURRICANE OR STORM-TIDE FLOOD LEVELS

The heights of tidal flooding experienced at a number of locations along the Connecticut coastal area during Hurricane "Carol" (1954) were obtained in the field and the elevation of these flood levels were determined by a field level party and referred to mean sea level. This information was supplemented by material on high water levels collected by the Corps of Engineers after the September 1938 hurricane. Based on these data, profiles have been prepared for the 1938 and 1954 tidal flood elevations between Willets Point, New York, at the western end of Long Island Sound, and Wareham, Massachusetts, at the eastern end of Buzzards Bay. Profiles of 1938 and 1954 flood levels along the Connecticut coast are shown in the main report.

C-4. STANDARD PROJECT HURRICANE

A Standard Project Hurricane has been established with the cooperation of the U. S. Weather Bureau and the Coastal Engineering Research Center (formerly the Beach Erosion Board) assisted by the Texas Agricultural and Mechanical Research Foundation. In selecting the Standard Project Hurricane, the 1944 Hurricane, which when off Cape Hatteras, had the greatest amount of energy of any recorded storm along the Atlantic Coast, was transposed so that it would be over water between Cape Hatteras and the New England Coast, resulting in less rise in barometric pressure at the center of the storm during its travel than actually occurred in 1944. The transposed hurricane is assumed to advance in a due northerly direction at a forward speed of 40 knots (about 46 m.p.h.) in one case, 30

knots (about 34 m.p.h.) in a second case, with its center crossing the New England coast at a point 49 nautical miles (56 statute miles) west of Montauk Point, Long Island, near the eastern entrance to Long Island Sound. This storm track places the entrance to the Sound in the most critical area of the hurricane and produces the highest surges along the Connecticut shoreline of Long Island Sound. The maximum surge, at the eastern end of Long Island Sound, has been determined to be 13.4 feet. Routing this up the sound gives surges from 9.0 to about 13.0 feet at various locations along the sound. Adding the surges to the mean spring tide has been designated as the Standard Project Flood Level.

APPENDIX D

CONSIDERED PROTECTION PLANS

APPENDIX D

CONSIDERED PROTECTION PLANS

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APPENDIX D (Cont'd)

PLATES

Number	Title
D-1	Greenwich to Milford, Protection Projects
D-2	West Haven to Old Saybrook, Protection Projects
D-3	Old Lyme to Stonington, Protection Projects
D-4	Typical Sections

APPENDIX D

CONSIDERED PROTECTION PLANS

D-1. Studies have been made to determine the possibilities of protecting the flooded areas along the Connecticut shoreline of Long Island Sound and the Thames River which have not been previously covered by an interim hurricane survey report. Emphasis has been given to the areas in each community where the heaviest concentrations of tidal-flood damages have been experienced. The considered protection for an area consisted of one or more of the following structures along the shorefront:

a. Earth-filled dikes, rock-faced where exposed to wave attack, otherwise sodded and seeded.

b. Earth-filled, rock-faced barriers across streams, bays and/or coves, with gated or ungated openings for navigation.

c. Concrete walls.

d. Steel sheet pile bulkheads or walls.

e. The raising and widening of existing beaches by the placement of sand fill. This would provide a beach of greater width and higher berm than the beach fill needed solely for beach erosion control purposes. To secure protection against the record 1938 level of flooding, or some higher level, and to prevent overtopping, the sand fill would be augmented by the construction of a dike along the landward limit of the fill.

Provisions were also included for (1) dikes and/or walls connecting the ends of the shorefront protection to high ground in order to secure complete closure of the area to be protected, (2) facilities for handling interior drainage, (3) gate structures at dike crossings of highways and railroad, and (4) other appurtenant works. Brief descriptions of the flood situation in the respective communities covered by this report and of the considered protection for each are contained in the following paragraphs. Typical sections are shown on Plate No. 4. The locations of the considered protection are shown on Plates Nos. 1, 2, and 3.

D-2. GREENWICH

a. Shoreline. The Sound shoreline of the town measures about 11.9 miles of which about 8.2 are privately owned. The total tidal shore line, including the tidal reaches of the lower Byram River, Cos Cob Harbor and the lower Mianus River, Greenwich Cove, and other identations, is approximately 26 miles.

b. Tidal Flooding and Damages. The flood levels and losses in recurring hurricanes of 1938 and 1954 severity are listed below:

Hurricane	Stage (west to east) (feet msl)	Recurring Loss
1938	11.7 to 11.1	$890,000
1954	11.0 to 10.4	700,000

In a Standard Project Hurricane flooding would be experienced to a stage varying in elevation from 15.8 to 14.9 feet msl, west to east.

The damages are scattered along the entire shoreline of the town. The losses in the Old Greenwich area of the town, between Greenwich Cove and Stamford Harbor, would account for over one-half of the total loss in a recurring 1954 hurricane.

c. Considered Protection. Consideration has been given to protecting three areas of the town against flooding to and above the record 1938 level. These plans were:

(1) Diking along the east side of Strickland Road, south of East Putnam Avenue, to protect properties in flooded area on north and south sides of Loughlin Avenue, in the Cos Cob section of the town.

(2) Diking along the shore to protect the flooded area east of Shore Road and south of Wood Road, in the Rocky Point area.

(3) Diking along the shore and across portions of Greenwich Cove to protect the flooded area at the head of the cove, south of Edgewater Drive and west of Sound Beach Avenue, in Old Greenwich.

D-3. STAMFORD

The authorized project for this city is described in House Document No. 210, 86th Congress, 1st Session.

D-4. DARIEN

a. Shoreline. The town has a shoreline along the Sound of about 6.0 miles, of which about 0.6 mile is publicly owned; and a total shoreline, including Holly Pond, the lower Fivemile River and other indentations, of about 15 miles.

b. Tidal Flooding and Damages. The flood levels and losses

in recurring hurricanes of 1938 and 1954 severity are listed below:

Hurricane	Stages (feet msl)	Recurring Loss
1938	11.0	$620,000
1954	10.3	480,000

In a Standard Project Hurricane flooding would be experienced to a stage varying in elevation from about 14.6 to 14.3 feet msl, west to east.

The losses are scattered over the entire shoreline of the town. Over one-half of the losses along the sound, or about one-third of the town losses, in a recurring 1938 or 1954 hurricane, would be in the nature of damage to grounds, seawalls, piers and other shorefront structures.

c. Considered Protection. No particular plan was studied. The nature of the damage, its wide distribution, and the frequency of its recurrence are such as to make studies of protective measures unwarranted at this time.

D-5. NORWALK

a. Shoreline. The city has a shoreline along the Sound of about 7.8 miles of which about 0.9 mile is publicly owned. The total shoreline, including the navigable portions of Fivemile River and Norwalk Harbor and River, and the shores of other indentations, is approximately 17 miles.

b. Tidal Flooding and Damages. The flood levels and losses in recurring hurricanes of 1938 and 1954 severity are listed below:

Hurricane	Stage (west to east)	Recurring Loss
1938	11.0 to 10.7	$2,100,000
1954	10.3 to 10.2	1,200,000

In a Standard Project Hurricane flooding would be experienced to a stage varying in elevation from about 14.3 feet to 13.8 feet msl, west to east.

The damages are scattered along the entire shoreline with three areas mentioned below, accounting for over 70 percent of the total.

c. Considered Protection. Consideration has been given to protecting three areas of the city against tidal flooding to and above

the record 1938 level. These plans were:

(1) Protection of the flooded area between the Fivemile River and Farm Creek by construction of concrete walls along the lower reach of the Fivemile River, with dike connections to high ground, and diking to prevent overflow from Farm Creek.

(2) Protection for Harborview by sandfill and diking along the east and north shores of the area and diking along the west and south.

(3) Protection for the flooded area in South Norwalk, south of the railroad, by the construction of dikes and walls along the shore and parallel to and east of Water street to high ground on the west side of Woodward Avenue, south of Burnett Avenue.

D-6. WESTPORT

The authorized project for this town is described in House Document No. 412, 87th Congress, 2nd Session.

D-7. FAIRFIELD

Considered protection for this town is covered in House Document No. 600, 87th Congress, 2nd Session.

D-8. BRIDGEPORT

a. Shoreline. The city has a shoreline along the Sound of about 5.9 miles of which about 5.0 miles, mainly sandy beach, is publicly owned. The total tidal waterfrontage of the city, including the banks of the improved portions of Black Rock Harbor and Cedar Creek, the Poquonock River, Yellow Mill Channel, and Johnson's River, extends approximately 20 miles.

b. Tidal Flooding and Damages. The flood levels and losses in recurring hurricanes of 1938 and 1954 severity are listed below:

Hurricane	Stages (feet msl) L.I. Sound (west to east)	Poquonock River	Recurring Loss
1938	10.0 to 9.2	9.5	$2,000,000
1954	9.4 to 9.2	9.9	880,000

In a Standard Project Hurricane, flooding along the Sound could be experienced to a stage varying in elevation from about 13.3 to 13.2 feet, msl, west to east; and to an elevation of about 14.3 feet msl in the Poquonock River.

The damages are located along the entire shoreline of the city. In a recurrence of the 1954 hurricane over one-half of the damage would be industrial in nature and largely to plants in the Cedar Creek and Tongue Point areas.

c. Considered Protection. Consideration has been given to providing protection in two areas of the city against flooding to and above the record level. The plans consisted of the following:

(1) Protection for the flooded area south of the main line of the New Haven Railroad and east of Iranistan Avenue by (a) raising Iranistan Avenue from near Park Place to Barnum Boulevard and raising Barnum Boulevard from Iranistan Avenue to Main Street, (b) constructing a dike along the shore at the inner end of Tongue Point, and (c) constructing a concrete wall from the end of the dike, along Henry Street, to high ground north of the United Illuminating Company property.

(2) Protection for property at the inner end of Tongue Point, east of Main Street and south of Henry Street, by ringing the property with a dike along the shore and concrete walls along the other three sides.

(3) Protection for industrial property on the west bank of the Poquonock River, above and below Grand Street, by the installation of steel sheet piling along the riverfront below Grand Street and diking to a point about 800 feet above Grand Street, together with necessary tie-back walls to high ground, a pumping station, and other appurtenant works.

D-9. STRATFORD

A plan of protection for this town was recommended by the Chief of Engineers in an interim hurricane survey report dated 29 January 1964.

D-10. MILFORD

a. Shoreline. The town has a shoreline along the Sound of about 10.0 miles and a total shoreline, including the banks of the Housatonic, Wepawaug, and Indian Rivers, of about 20.0 miles. Approximately 20 percent of the Sound shorefront is in public ownership,

b. Tidal Flooding and Damages. The record level of tidal flooding, experienced in the hurricanes of September 1938 and August 1954, ranged from 9.2 feet msl at the west to 9.45 feet msl at the east. In a Standard Project Hurricane flooding could be experienced to a stage ranging from 13.3 to 14.4 feet msl, west to east.

The losses today, in a recurrence of the record tidal-flood level, would amount to an estimated $530,000. These losses would be scattered along the entire waterfront with the three areas of major damage being (1) the shorefront from Cedar to Fort Trumbull Beach, (2) the residential area at Bayview, east of Welches Point, and (3)the residential area at Point Beach and Pond Point.

c. Considered Protection. Consideration has been given to the following plans for protection to and above the record level of flooding:

(1) Protection for the flooded area along the Sound, from the west end of Cedar Beach, near foot of Francis Street, to west end of Fort Trumbull Beach, a few hundred feet west of the foot of Seaside Avenue,by sandfill and diking along the shore.

(2) Protection for the Bayview area by sandfill and diking along the shore with tie-back dikes to high ground beyond the east and west ends of Field Court.

(3) Protection for the Point Beach-Pond Point area by diking along the shore from near the west end of Morehouse Avenue, around Pond Point, to near the south end of Westmoor Road.

D-11. WEST HAVEN

a. Shoreline. The Sound shoreline of the town measures about 4.3 miles of which about 3.0 miles is in public ownership. The total tidal shoreline, including the New Haven Harbor area of the town, is about 7.0 miles.

b. Tidal Flooding and Damages. The record level of tidal flooding experienced in the September 1938 and August 1954 hurricanes, is 9.5 feet msl. In a Standard Project Hurricane flooding could be experienced to a stage ranging from 14.4 to 15.0 feet msl, west to east.

The losses today, upon the recurrence of the record tidal-flood level, would amount to an estimated $240,000. The damages would be scattered along the entire shoreline with the greatest concentration being located along the 2000 feet of shore at the west limit of the town. Other areas of important damages are at Bradley Point and along the New Haven Harbor waterfront below the mouth of West River.

c. Considered Protection. Consideration has been given to protecting three areas of the town against flooding to and above the record level. These plans were:

(1) Protection for properties in the Oyster River Beach area by diking along approximately 1,000 feet of shore and sandfill and diking along 700 feet.

(2) Protection for flooded area at Bradley Point by the construction of diking around the Point, augmented in places by sandfill, plus tie-back dikes to high ground, street gates, and other appurtenant measures.

(3) Protection for the industrial properties along the waterfront at the eastern end of the town by diking along the shore between Elm Street and Main Street, extended, plus tie-back diking and other supplemental work.

D-12. NEW HAVEN

a. Shoreline. The city has a total tidal shoreline, including New Haven Harbor and the Mill and Quinnipiac Rivers, of over 15 miles of which slightly over two miles, in the vicinity of Lighthouse Point, are along the Sound and the outer portion of New Haven Harbor.

b. Tidal Flooding and Damages. The record level of tidal flooding, experienced in the hurricanes of September 1938 and August 1954, is 9.5 feet msl. In a Standard Project Hurricane flooding could be experienced to a stage ranging from 15.0 feet msl at the west to 15.3 feet msl at the east.

The losses today, in a recurrence of the record tidal-flood level, would amount to an estimated $1,040,000. The damages would be principally located in the waterfront area at the head of the harbor, along the banks of the Mill and Quinnipiac Rivers, and along the east shore of the harbor.

c. Considered Protection. Consideration has been given to the possibilities of protecting several locations in the city where the damages would be relatively high in the event of future flooding to or above the record level and where protection might conceivably be located without seriously interfering with the operation of waterfront terminals and other facilities. The several considered plans were as follows:

(1) Protection for all or portions of the flooded area in the Fair Haven section of the city by the construction of dikes and walls, with appurtenant measures, along the bank of Mill River, from the vicinity of Humphrey Street to the mouth of the river, then up the

Quinnipiac River to near the foot of Pine Street.

(2) The construction of dikes and walls, with pumping station, tie-back dikes, and other related works, along the south or left bank of the Quinnipiac River to afford protection for the major part of the flooded industrial area between the Connecticut Turnpike and Ferry Street.

D-13. EAST HAVEN

a. Shoreline. The town has a total shoreline along the Sound of approximately 2.3 miles. The entire shorefront, with the exception of a few street ends, is privately owned.

b. Tidal Flooding and Damages. The record level of tidal flooding, experienced in the September 1938 and August 1954 hurricanes, is 9.5 feet msl. In a Standard Project Hurricane flooding could be experienced to a stage ranging in elevation from 15.3 to 15.5 feet msl, west to east.

The losses today, upon the recurrence of the record tidal-flood level, would amount to an estimated $700,000. The damages are scattered along the entire shoreline with the greater concentrations being at West Silver Sands, Silver Sands, and Momauguin Beaches.

c. Considered Protection. Consideration has been given to a number of plans that would afford protection to all or various sections of the waterfront from the west end of West Silver Sands Beach to and around Mansfield Point at the east end of Momauguin Beach, against flooding to and above the record level, by the placement of sandfill and diking along the shore.

D-14. BRANFORD

a. Shoreline. The shoreline of the town, along the Sound, measures about 12.0 miles. It is all in private ownership. The total tidal shoreline of the town, including East Haven River, Branford River, and Stony Creek, but excluding islands, extends a distance of over 21.0 miles.

b. Tidal Flooding and Damages. The record level of tidal flooding, experienced in the September 1938 and August 1954 hurricanes, is 9.5 feet msl. In a Standard Project Hurricane flooding could be experienced to a stage ranging in elevation from 15.5 feet msl at the west to 15.6 feet msl at the east.

The losses today, upon the recurrence of the record tidal-flood level, would amount to an estimated $1,350,000. Over 84 percent of the total damage would be to properties along the banks of Branford River

above Branford Point with over 80 percent of the total being located at and near the head of navigation.

c. Considered protection. Consideration has been given to three general plans that would afford flooded areas along Branford River with protection to and above the record level. These plans are:

(1) Dike and wall protection along the right or north bank of the river, from a point about 600 feet above the Indian Neck Avenue Bridge to a point about 2,000 feet below the bridge.

(2) A rock-faced, earth-filled barrier across Branford River at Branford Point, with a navigation opening 75 feet wide, equipped with gates to either completely or partially close the opening during a hurricane.

(3) A barrier across Branford Harbor, running approximately west from Indian Neck Point to the general vicinity of Double Beach, with a partially-gated navigation opening 75 or 100 feet wide.

D-15. GUILFORD

a. Shoreline. The tidal shoreline of the town, including the bays, coves, and harbors along the Sound but excluding the banks of the East and West Rivers, measures nearly 12 miles. This is all in private ownership with the exception of 800 feet of publicly-owned shore.

b. Tidal Flooding and Damages. The record level of tidal flooding, experienced in the September 1938 and August 1954 hurricanes, is 9.4 feet msl. In a Standard Project Hurricane flooding could be experienced to a stage ranging in elevation from 15.6 to 15.8 feet msl, from west to east.

The losses today, upon the recurrence of the record tidal-flood level, would amount to an estimated $190,000. The damages are scattered over a number of locations along the entire shoreline with no significant concentrations.

c. Considered Protection. Consideration has been given to four general plans for providing flooded areas along the Sound with protection to and above the record level. These plans were as follows:

(1) Diking around flooded residential properties at Vineyard Point. 15a

(2) Diking around the industrial plant located between the West River and Whitfield Street, south of the railroad, which would begin to sustain damages of consequence with flooding to a stage two feet above the record level.

(3) Diking around the residential properties on both sides of Seafield Avenue, from Whitfield Street south to Guilford Point.

(4) Diking around residential properties at the east end of Whitfield Street, at the head of the navigation project in Sluice Creek.

D-16 MADISON

a. Shoreline. The town has a shoreline along the Sound of about 7.4 miles of which about 2.3 miles are publicly owned. The total tidal water frontage is about 9 miles.

b. Tidal Flooding and Damages. The record level of tidal flooding, experienced in the September 1938 and August 1954 hurricanes, ranged from 9.4 feet msl at the west to 9.3 feet msl at the east. In a Standard Project Hurricane flooding could be experienced to a stage ranging from 15.8 to 15.7 feet msl west to east. The losses today, upon the recurrence of the record tidal flood level, would amount to an estimated $700,000. The losses are located along the entire shoreline. About 30 percent of the total would be along 2600 feet of shore in the Canoe Harbor-Overshore area and 20 percent along the one mile of shore west of Chipman Point.

c. Considered Protection. Protection was considered for an area of concentrated damage between Oak Avenue and Shoreland Drive against flooding to and above the record level. It consisted of raising and widening the existing beach by the placement of sand fill and constructing a back-up dike along the landward edge of the fill and tie-back dikes to high ground.

D-17. CLINTON

a. Shoreline. The town has a shoreline along the Sound of 4.8 miles of which about 1.2 miles are publicly owned and principally sandy beach. The total tidal shoreline, including the tidal portion of Clinton Harbor and other inlets, is about 12 miles.

b. Tidal Flooding and Damages. The flood levels and losses in recurring hurricanes of 1938 and 1954 severity are listed below:

Hurricane	Stage (feet msl)	Recurring Loss
1938	9.3	$260,000
1954	9.2	220,000

In a Standard Project Hurricane flooding could be experienced to approximately 15.6 feet msl.

The losses are located along the entire shoreline of the town and consist largely of damage to summer cottages, seawalls, and grounds. The two areas of heaviest damage are the Harbor View section on the east side of Clinton Harbor and the riverfront area on the north bank of the Hammonasset River, east of the town dock at the foot of Maplewood Drive.

c. Considered Protection. Consideration has been given to providing protection in two areas of the town against flooding to and above the record level. The plans consisted of the following:

(1) A dike completely enclosing the Harbor View area.

(2) Dikes and walls along the north shore of the Hammonasset River, with closure dikes to high ground, to provide protection to the flooded area between Maplewood Drive and Commerce Street.

D-18. WESTBROOK

a. Shoreline. The Sound shoreline of Westbrook measures about 4.3 miles of which 3.7 miles principally sandy beach, is privately owned. The total tidal shoreline is about 5 miles.

b. Tidal Flooding and Damages. The flood levels and losses in recurring hurricanes of 1938 and 1954 severity are listed below:

Hurricane	Stage (west to east) (feet msl)	Recurring Loss
1938	9.3 to 9.4	$860,000
1954	9.2	700,000

In a Standard Project Hurricane flooding along the Sound would be experienced to a stage varying in elevation from 15.5 to 15.2 feet msl, west to east.

The damages are scattered along the entire shorefront of the town The heaviest concentrations are found along the 4200 feet of shorefront in the West Beach area, which includes the Coral Sands Development, and along the shore at Middle Beach.

c. Considered Protection. Consideration has been given to protection of three areas in the town against flooding to and above the record 1938 level. These plans are:

(1) Protection of the West Beach area by sand fill and diking along the shore with necessary closure dikes to high ground.

(2) Diking around the summer cottages at Coral Sands.

(3) Sand fill and diking along Middle Beach with closure dikes to high ground.

D-19 OLD SAYBROOK

a. Shoreline. The Sound shoreline of the town measures about 5.6 miles. This is all privately owned with the exception of 180 feet of town-owned beach. The total tidal shoreline, including the Connecticut River, is about 23 miles.

b. Tidal Flooding and Damages. The flood levels and losses in recurring hurricanes of 1938 and 1954 severity are listed below:

Hurricane	Stage (feet msl)	Recurring Loss
1938	9.4	$1,370,000
1954	9.2	1,180,000

In a Standard Project Hurricane flooding along the Sound would be experienced to a stage varying from 15.2 to 14.9 feet msl, west to east.

The damages are scattered along the entire Sound shoreline of the town with the greatest concentration amounting to about two-thirds of the total damage, being located west of Oyster River. The major part of this loss, in turn, would be in the Chalker Beach area.

c. Considered Protection. Consideration was given to protecting two areas of the town against flooding to and above the record level. These plans were:

(1) Diking and sand fill from the town line, near the mouth of Coldspring Brook, along Chalker Beach and the Indiantown and Saybrook Manor areas, to the mouth of Oyster Creek, with tie-back dikes to high ground to complete closure. Several alternate closures were studied.

(2) Protection of residential development at Great Hammock Beach by the construction of dikes and/or walls, around entire perimeter of the settlement.

D-20 OLD LYME

a. Shoreline. The town has a shoreline along the Sound of about 5.5 miles which is all privately owned with the exception of 150 feet of

public beach. The total tidal shoreline, including the Connecticut River, is about 23 miles.

b. Tidal Flooding and Damages. The flood levels and losses in recurring hurricanes of 1938 and 1954 magnitude are listed below:

Hurricane	Stage (west to east) (feet msl)	Recurring Loss
1938	9.4 to 9.5	$1,980,000
1954	9.1	1,700,000

In a Standard Project Hurricane flooding would be experienced to a stage ranging from 14.9 to 14.7 feet, msl. west to east.

The damages are scattered along the entire shorefront. The major concentrations of damage are found at White Sands Beach, west of Brighton Point; the Hawks Nest area, west of Sound View Creek; the Sound View to Old Lyme Shores area, west of Sound View Creek; and the Point O'Woods section of the town.

c. Considered Plans. Consideration was given to protection at White Sands Beach, Sound View Beach, and Point O'Woods against tidal flooding to the record 1938 level and higher. The considered protection at each of the three locations consisted of raising and widening the existing beach by the placement of sand fill and constructing a back-up dike along the landward edge of the fill and necessary tie back dikes to high ground.

D-21 EAST LYME

a. Shoreline. The Sound shoreline of the town measures about 6.8 miles of which about one mile is publicly owned. The total tidal shoreline extends about 18 miles.

b. Tidal Flooding and Damages. The flood levels and losses in recurring hurricanes of 1938 and 1954 severity are listed below:

Hurricane	Stage (west to east)	Recurring Loss
1938	9.5 to 9.6	$1,070,000
1954	9.0 to 8.9	990,000

In a Standard Project Hurricane flooding would be experienced to a stage varying in elevation from 14.7 to 14.4 feet msl, west to east.

The damages are scattered along most of the waterfront with the greatest concentration being located along the west shore of Niantic Bay from the Black Point Beach Club to Crescent Beach.

c. Considered Plan. Consideration was given to the protection of the flooded area in the vicinity of Oak Beach against flooding to and above the record 1938 level. The considered plan consisted of sand fill and diking along the shore with necessary tie-back dikes to high ground.

D-22. WATERFORD

a. Shoreline. The town has a shorefront along the Sound of about 7.3 miles of which about one mile is publicly owned. The total tidal shoreline, including the Niantic River and the west bank of the Thames River, is about 22 miles.

b. Tidal Flooding and Damages. The flood levels and losses in recurring hurricanes of 1938 and 1954 severity are listed below:

Hurricane	Stage (feet msl)		Recurring Loss
	L.I. Sound (west to east)	Thames R. (south to north)	
1938	9.6 to 9.7	10.2 to 11.4	$370,000
1954	8.9	9.1 to 9.4	310,000

In a Standard Project Hurricane flooding would be experienced to a stage varying in elevation from 14.4 to 14.1 feet msl along the Sound, from west to east, and from 14.8 to 16.7 feet msl along the Thames River, from south to north.

The damages are scattered along the entire shoreline with the principal concentrations being located at the head of Niantic Bay and in the Ridgewood area on the west bank of Alewife Cove. Much of the loss in the town, in 1954, was damage to boats.

In view of the nature of the damage and the fact that it extends over relatively long lengths of shorefront, protection against tidal flooding was not considered.

D-23. NEW LONDON

a. Report Area and Shoreline. This report covers the 1.3 miles of the city's shoreline along the Sound from the entrance of Alewife Cove to Quinnipeag Rocks. The remainder of the New London waterfront area with a total length of about 8.5 miles, is included in the authorized project described in House Document No.478, 87th Congress, 2nd Session.

b. Tidal Flooding and Damages. The flood levels and losses in the study area along the Sound, in recurring hurricanes of 1938 and 1954 severity, are listed below:

Hurricane	Stage (feet msl)	Recurring Loss
1938	9.7	$540,000
1954	8.9	500,000

In a Standard Project Hurricane flooding would be experienced to a stage of 14.0 feet msl.

Approximately one-half of the damages in the study area would be sustained at the amusement park at Ocean Beach and one-third in the Neptune Park Area.

The total losses in New London, including the area covered in the previous study, assuming no hurricane protection plans in operation, are estimated at $5,500,000 for a recurring 1938 hurricane and $4,280,000 for a recurring 1954 hurricane.

c. Considered Plan. Consideration was given to the protection of Ocean Beach against flooding to and above the record 1938 level by sand fill and diking along the shore with necessary tie-back dikes to high ground.

In connection with studies of protection for flooded properties in Groton, on the east shore of New London Harbor, consideration was given to a number of plans for breakwater protection in the harbor. Several of these plans would also afford some protection, through reduction in wave heights, to properties along the New London shore outside the authorized project protection. (See Paragraph D-28c).

D-24 MONTVILLE

a. Shoreline. The tidal shoreline of the town along the west bank of the Thames River measures about 9 miles.

b. Tidal Flooding and Damages. The flood levels and losses in recurring hurricanes of 1938 and 1954 levels are listed below:

Hurricane	Stages (south to north) (feet msl)	Recurring Loss
1938	11.4 to 13.7	$910,000
1954	9.4 to 10.1	700,000

In a Standard Project Hurricane flooding would be experienced along the river to a stage varying in elevation from about 16.7 to 20.0 feet msl south to north.

Practically all of the damage, industrial in nature, is located at Montville Station.

c. Considered Protection. Consideration has been given to protection of the industrial property at Montville Station against flooding to and above the record 1938 level, by construction of dikes and walls along the river with tie-back dikes to high ground at the railroad embankment.

D-25 NORWICH

a. Shoreline. The city has a tidal shoreline along the west bank of the Thames River, below the junction of the Yantic and Shetucket Rivers, of about 2.7 miles, and along the east bank of 3.4 miles, a total of 6.1 miles.

b. Tidal Flooding and Damages. The flood levels and losses in recurring hurricanes of 1938 and 1954 magnitude are listed below:

Hurricane	Stages (south to north)	Recurring Loss
1938	13.7 to 15.1	$5,160,000
1954	10.1 to 10.6	1,140,000

In a Standard Project Hurricane flooding would be experienced to a stage varying in elevation from about 20.0 to 22.0 feet msl, south to north.

The major concentration of damages is at Thamesville, an industrial area on the west bank of the river. The balance of the damage is at scattered locations.

c. Considered Protection. Consideration has been given to protection of the Thamesville area against flooding to and above the 1938 level by the construction of a system of shore front dikes and concrete walls together with tie-back dikes to high ground and other appurtenant works, including a pumping station.

D-26 PRESTON

a. Shoreline. The town has a tidal shoreline along the east bank of the Thames River, including Poquetanuck Cove, of approximately 4.7 miles.

b. Tidal Flood Levels. The flood levels in recurring hurricanes of 1938 and 1954 severity are listed below:

Hurricane	Stages (south to North) (feet msl)
1938	12.8 to 13.7
1954	9.8 to 10.1

In a Standard Project hurricane flooding would be experienced to a stage varying in elevation from about 18.8 feet to 20.0 feet msl, south to north.

c. Considered Protection. The losses from tidal flooding have been minor in amount in past hurricanes. In view of this, hurricane protection has not been considered.

D-27. LEDYARD

a. Shoreline. The town has a tidal shoreline along the east bank of the Thames River of 7.5 miles.

b. Tidal Flood Levels. The flood levels in recurring hurricanes of 1938 and 1954 severity are as follows:

Hurricane	Stages (south to north) (feet msl)
1938	10.6 to 12.8
1954	9.1 to 9.8

In a Standard Project Hurricane flooding would be experienced to a stage varying in elevation from about 15.4 to 18.8 feet msl, south to north.

c. Considered Protection. No particular plan was studied as the reported damages were minor and at scattered locations along the shoreline.

D-28. GROTON

a. Report area and Shoreline. This report covers the Area of Groton to the west of the head of West Cove in the Noank section of the town. The total tidal shoreline in the report area of the town is nearly 30 miles of which about 7 miles are along the Sound proper, 6.5 miles along the east bank of the Thames River, and 16.5 miles along the Poquonock River, Baker, Mumford, Palmer Coves and other identations. The remainder of the Groton waterfront area, with a shoreline of about 10 miles, is included in the authorized project for Mystic River and Harbor described in House Document No. 411, 87th Congress, 2nd Session.

b. Tidal Flooding and Damages. The flood levels and losses in recurring hurricanes of 1938 and 1954 severity are listed below:

Hurricane	Stages (feet msl)		Recurring Loss
	L.I. Sound (west to east)	Thames R. (south to north)	
1938	9.7 to 10.3	9.7 to 10.6	$5,090,000
1954	8.9 to 8.8	8.9 to 9.1	2,620,000

In a Standard Project Hurricane flooding would be experienced to a stage of 14.0 feet msl along the Sound and to a stage ranging from 14.0 to 15.4 feet msl, south to north, along the Thames River. The major portion of the losses are located in the Groton Long Point area, between Mumford and Palmer Coves. The balances of the losses would be at scattered locations along the shore, particularly at Eastern Point and Jupiter Point.

The total losses in Groton, including the area covered in the previous report, and assuming no hurricane protection plans in operation, are estimated at $5,090,000 for a recurring 1938 hurricane and $2,620,000 for a recurring 1954 hurricane.

c. Considered Protection. Consideration has been given to partial protection for Groton Long Point area, against tidal flooding to the record 1938 level, by means of the following.

(1) The placement of sand fill to raise and widen approximately 900 feet of South Beach, west of Groton Long Point, and 2,600 feet of Main Beach, east of Buddington Point, and the construction of a low precast concrete wall backstop along the landward limit of the fill.

(2) The construction of diking along the rocky east shore of the point.

(3) The construction of a barrier, with a partially-gated navigation opening, across the entrance to Mumford Cove.

A preliminary study has been made of breakwater protection for the New London Harbor area which would reduce wave heights in Groton, on the east shore, and in New London, outside the authorized project protection, on the west. Five plans were considered calling for breakwaters at a number of alternate locations in the outer half of the harbor, from south of Fort Trumbull and the Electric Boat Division to the harbor entrance, outside of Eastern Point. Four of the five plans necessitate a relocation of the main navigation channel.

D-29. STONINGTON

a. Report Area and Shoreline. This report covers the area of Stonington bordering the Sound from a point about 3000 feet west of the entrance to Wequetequock Cove. This area has a shoreline along the Sound

of about 8 miles and a total tidal shoreline, including Stonington Harbor and other identations, of about 18 miles. The Mystic River and Harbor and Pawcatuck River areas of the town, with a total shoreline of about 28 miles, are included in authorized projects described in House Documents Nos. 411, 87th Congress, 2nd Session, and 212, 86th Congress, 1st Session.

b. Tidal Flooding and Damages. The flood levels and losses in recurring hurricanes of 1938 and 1954 severity are listed below:

Hurricane	Stages (west to east) (feet msl)	Recurring Loss
1938	10.4	$4,160,000
1954	8.9 to 9.4	2,935,000

In a Standard Project Hurricane flooding would be experienced to a stage varying in elevation from about 14.3 to 14.6 feet msl, west to east.

Over 90 percent of the damage in the report area would be at Stonington Village, on Stonington Point, with most of the balance being located in the Lords Point area.

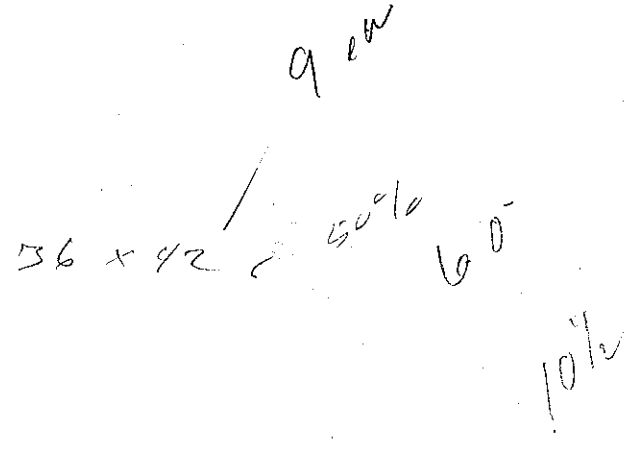
(Total losses in the town, including areas covered in previous studies, assuming no hurricane protection plans in operation, are estimated at $7,700,000 for a recurring 1938 hurricane and $4,920,000 for a recurring 1954 hurricane).

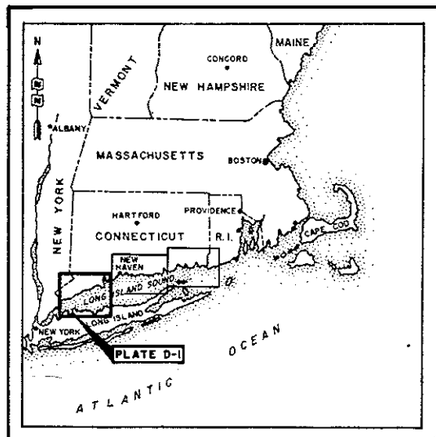
c. Considered Protection. Consideration has been given to protection of two areas of the town against tidal flooding to and above the record 1938 level. These plans were as follows:

(1) Protection for the flooded area extending along the shore from the west end of White Beach, near the entrance to Quambaug Cove, to the east side of Lords Point by sand fill and diking along the rocky portions of the shore, plus necessary tie-back dikes to high ground and other appurtenant works.

(2) Protection at Stonington Village for the flooded area north of the railroad, near the head of Stonington Harbor, and just south of the railroad, at the inner end of Stonington Point, by diking along the north side of the railroad and the banks of Stonington Harbor and Quanaduck Cove, and sand fill and diking along the east and northeast shore of Stonington Point, northwest of the entrance to Little Narragansett Bay.

(3) Raising and extending the existing inner breakwater on the west shore of Stonington Point.





LOCATION MAP

SCALE IN MILES

25 0 25 30

LEGEND

Recommended, Authorized or Constructed Projects.

Considered Projects.

HURRICANE SURVEY

CONNECTICUT COASTAL AND TIDAL AREAS

GREENWICH TO MILFORD

PROTECTION PROJECTS

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. MAY 1964
SCALE AS SHOWN

PLATE D-1

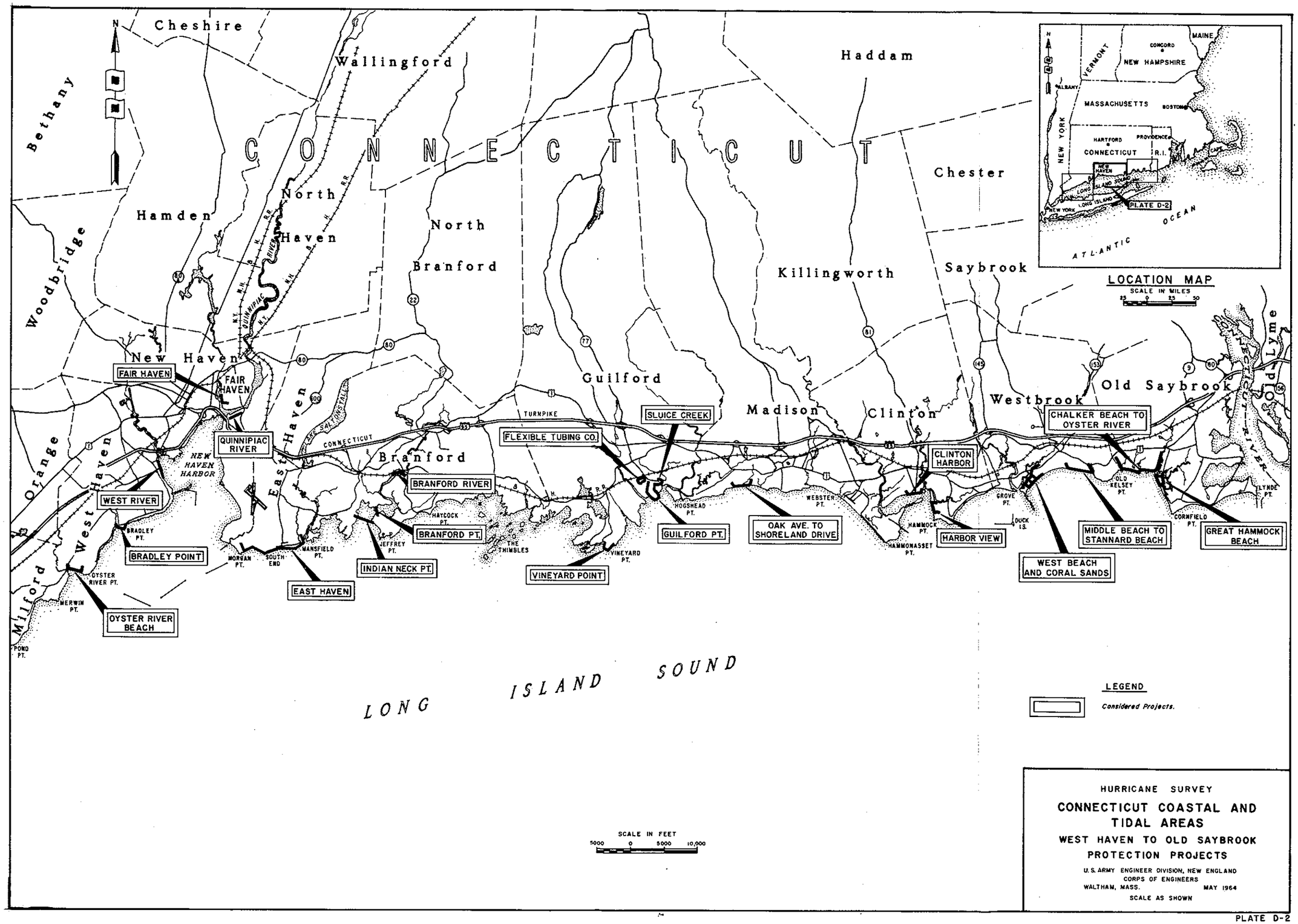
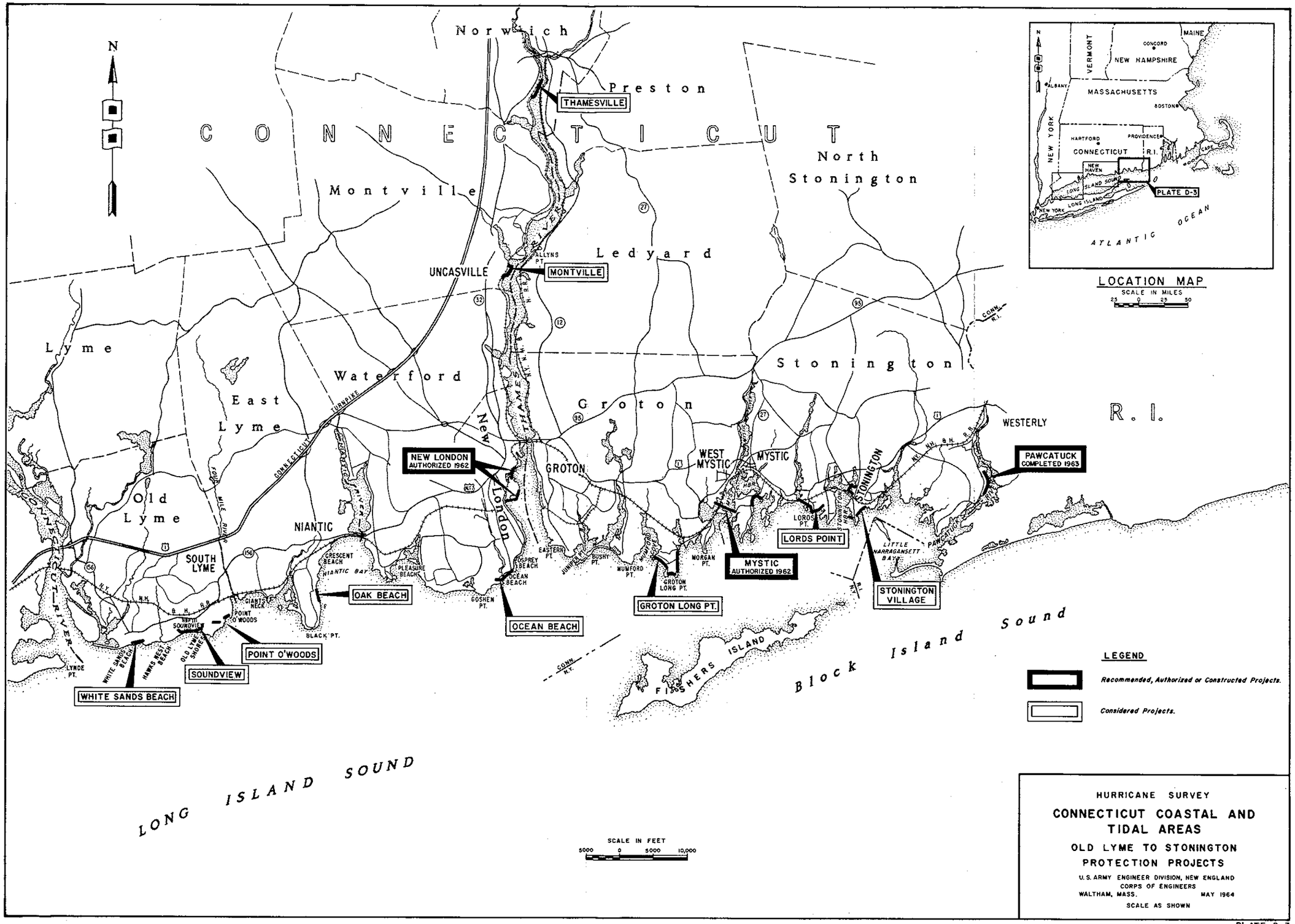

CONNECTICUT
LONG ISLAND SOUND
Cheshire
Wallingford
Bethany
Hamden
North Haven
North Branford
Haddam
Killingworth
Chester
Saybrook
Woodbridge
New Haven
Guilford
Madison
Clinton
Westbrook
Old Saybrook
Old Lyme
Orange
West Haven
Milford
Branford
East Haven
FAIR HAVEN
QUINNIPIAC RIVER
NEW HAVEN HARBOR
WEST RIVER
BRADLEY POINT
OYSTER RIVER BEACH
EAST HAVEN
INDIAN NECK PT.
BRANFORD PT.
BRANFORD RIVER
VINEYARD POINT
FLEXIBLE TUBING CO.
SLUICE CREEK
GUILFORD PT.
OAK AVE. TO SHORELAND DRIVE
CLINTON HARBOR
HARBOR VIEW
CHALKER BEACH TO OYSTER RIVER
MIDDLE BEACH TO STANNARD BEACH
WEST BEACH AND CORAL SANDS
GREAT HAMMOCK BEACH
TURNPIKE
CONNECTICUT
LAKE SALTONSTALL
N.Y. N.H. H.R.R.
QUINNIPIAC RIVER
PLATE D-2
LOCATION MAP
SCALE IN MILES
MAINE
VERMONT
NEW HAMPSHIRE
MASSACHUSETTS
CONNECTICUT
R.I.
ATLANTIC OCEAN
LEGEND
Considered Projects.
SCALE IN FEET
5000 0 5000 10,000
HURRICANE SURVEY
CONNECTICUT COASTAL AND TIDAL AREAS
WEST HAVEN TO OLD SAYBROOK
PROTECTION PROJECTS
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. MAY 1964
SCALE AS SHOWN

PLATE D-2



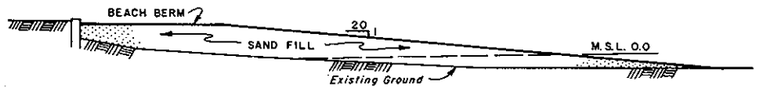
HURRICANE SURVEY

CONNECTICUT COASTAL AND TIDAL AREAS

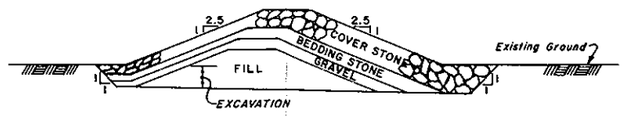
OLD LYME TO STONINGTON PROTECTION PROJECTS

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. MAY 1964
SCALE AS SHOWN

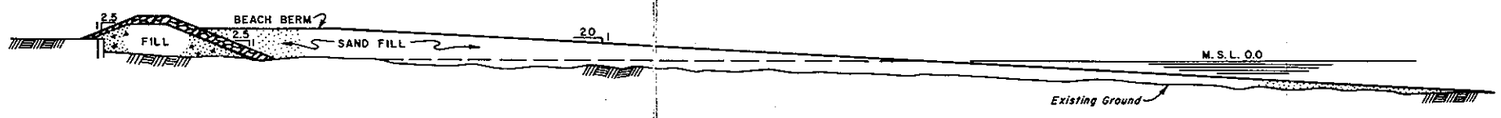
PLATE D-3



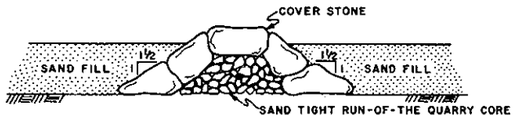
TYPICAL BEACH EROSION SAND FILL



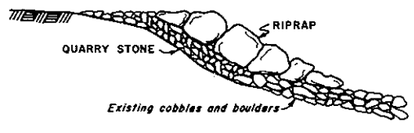
TYPICAL DIKE



TYPICAL BEACH RAISING AND WIDENING



TYPICAL GROIN SECTION



TYPICAL REVETMENT

HURRICANE SURVEY

CONNECTICUT COASTAL AND TIDAL AREAS

TYPICAL SECTIONS

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. MAY 1964
NOT TO SCALE